The role of dry cat food in causing common feline disorders is currently under considerable debate. Because of accessibility to the Internet and related social media, clients have more questions than ever regarding the role of nutrition in pet health. It has been suggested that consumption of carbohydrate in dry commercial cat foods is causing the increased incidence of feline diseases such as diabetes mellitus and obesity and that feeding low-carbohydrate, moist foods is indicated to help prevent or manage these conditions.

Because client education is an important role of veterinary technicians, technicians should stay current on the latest veterinary knowledge, especially pertaining to veterinary nutrition. This article (1) summarizes the current knowledge regarding the association between carbohydrate (and dry food) and feline diseases and (2) reviews evidence that supports feeding low-carbohydrate or canned foods to cats. Informed with the latest research, veterinary technicians should be able to knowledgeably discuss the benefits of dry foods and wet foods with pet owners.

Cats and Carbohydrate

The natural prey of cats includes small rodents, which are estimated to contain approximately 55% protein, 45% fat, and 1% to 2% carbohydrate on a dry matter (DM) basis. The average carbohydrate content of dry grocery-brand cat foods is approximately 45% DM, whereas moist grocery-brand cat foods contain approximately 10% carbohydrate. Because of physiologic differences in cats (e.g., low hepatic glucokinase activity, decreased intestinal and pancreatic amylase activity) compared with dogs and the results of some studies evaluating carbohydrate digestion, it has been suggested that cats cannot efficiently use carbohydrate and that carbohydrate decreases protein digestibility. However, these studies included simple sugars (glucose) and raw carbohydrate, and most commercial pet foods contain complex carbohydrates that are cooked during the manufacturing process. Appropriately prepared (ground and cooked) carbohydrates are highly digestible (>90%) in cats and are not associated with clinically important decreases in protein digestibility.

A recommended dietary amount of carbohydrate does not exist for cats (or dogs). However, carbohydrate is an excellent source of energy. Most cells use glucose as their primary source of energy. Dietary carbohydrate is a readily available source for glucose production. In the absence of carbohydrate, amino acids are diverted from protein synthesis to glucose production (i.e., gluconeogenesis). For high energy needs in certain life stages (e.g., growth, gestation, lactation), carbohydrate becomes conditionally essential; therefore, foods for pets with high energy demands (e.g., lactating queens) usually contain an increased amount of carbohydrate. Additionally, carbohydrate provides structural integrity to dry food: starch works like a cement to strengthen kibble, hold it together, and prevent crumbling during manufacturing.

What Lifestyle and Management Factors Affect Feline Health?

It has been reported that cat owners prefer to feed dry food, which more than half of them feed free choice. In contrast, people who feed moist (e.g., canned) food give their cats one or two meals daily. One study identified dry food as a risk factor for obesity in cats. Several more recent studies revealed that free-choice feeding (using canned or dry food) was associated with excessive caloric intake and increased body weight and fat in spayed and neutered cats. In a study on neutered cats that ate a dry weight-management food free choice, the cats...
became overweight. Subsequently, when they were fed a controlled amount of the same food, they lost weight successfully. Free-choice feeding facilitates excessive caloric intake, which contributes to obesity; therefore, because of the feeding habits of cat owners, obesity is much more likely to occur with dry food. Veterinary technicians are responsible for educating owners about the risks of free-choice feeding and for developing a proper and healthy feeding plan with owners.

Several studies have confirmed a decrease in metabolic rate and physical activity and an increase in food intake, body weight, body condition score, and amount of body fat after spaying or neutering. Metabolic changes occur within days to weeks after spaying or neutering. In one study, caloric intake increased 25% 4 weeks after gonadectomy and 50% after 12 weeks. These changes appear to occur whether spaying or neutering is done at an early age (7 weeks) or later (7 months). After a patient is spayed or neutered, the veterinary technician should calculate the amount of food that the owner should feed and discuss it, along with the patient’s subsequent physiologic changes, with the owner. This can help the owner understand why and how nutrition is integral to feline health.

**Does Dry Food Cause Diabetes Mellitus or Obesity in Cats?**

When the role of dry food (and carbohydrate) in feline disease is evaluated, it is important to consider the changes to the feline lifestyle during the past several decades. Historically, cats were intact and free roaming and had a “job” to do. Today, most cats are indoor family pets, spayed or neutered, less physically active, and fed dry food. All, or some combination, of these factors have affected the incidence of feline disease, particularly obesity. In addition, most of the risk factors for being overweight or obese are also risk factors for diabetes mellitus in cats (i.e., male, neutered, older age, living indoors, low physical activity). Obesity has been associated with insulin resistance in cats, and obese cats that lose body fat have improved insulin sensitivity.

Several authors have suggested that high-carbohydrate foods cause, or may be a factor in the development of, diabetes mellitus and/or obesity in cats. The proposed mechanism is that consumption of high-carbohydrate dry foods causes hyperglycemia, which stimulates insulin release, leading to pancreatic β-cell exhaustion and overt diabetes mellitus. However, the results of most published studies do not support this theory. The following summarizes the main points from studies that have evaluated the potential role of dietary carbohydrate in the pathogenesis of diabetes mellitus and obesity in cats.

- Most commercial cat foods contain complex carbohydrates, not simple sugars; therefore, it is unlikely that cats eating dry foods would develop hyperglycemia. While consumption of simple sugars (e.g., glucose) resulted in increased blood glucose concentrations in healthy cats, cooked maize starch (a complex carbohydrate) did not. Feeding a variety of commercial dry and canned cat foods to healthy and diabetic cats was not associated with a significant change in blood glucose concentration. Compared with fasting values, no significant difference was found in postprandial serum glucose concentrations when cats were fed two dry commercial foods that had 37% or 42% carbohydrate DM. There was a significant decrease (compared with the higher carbohydrate diet) in serum glucose concentrations when the cats were fed a dry food that had 16% carbohydrate and 52% protein DM, and serum insulin concentrations increased significantly. The food containing the highest amount of carbohydrate (42% DM) and lowest amount of protein (35% DM) was associated with the lowest serum insulin concentration. The feline pancreas appears to be more responsive to amino acids than to glucose; therefore, dietary protein may be more likely than carbohydrate to stimulate pancreatic insulin secretion in cats.

- In a study of healthy cats, feeding a high-protein (46% of calories) food to healthy cats was associated with lower postprandial glucose concentrations compared with a high-carbohydrate (47% of calories) or high-fat (47% of calories) food.

- In a different preliminary study, healthy cats fed a low-protein (28% of calories), low-fat (28% of calories), or low-carbohydrate (3% of calories) food had no significant differences in their glucose tolerance test results. The insulin concentrations of cats fed the low-carbohydrate food (which contained the highest protein) tended to be higher but within normal limits.

- In another preliminary study of healthy cats, feeding a high-protein (58% DM), low-carbohydrate (8% DM) food was associated with mixed results (in terms of blood glucose and insulin concentrations) compared with feeding a low-protein (33% DM), high-carbohy-
There was no difference between groups in their glucose concentrations after intravenous glucose challenge or consumption of food and no difference in insulin concentrations after intravenous glucose challenge. However, insulin concentrations were significantly higher after consumption of the low-protein, high-carbohydrate food.

- Healthy cats that ate a high-fat food (with 13% carbohydrate DM) had significantly higher plasma glucose concentrations during glucose tolerance testing compared with cats that ate a high-carbohydrate (40% DM), low-fat food. The authors concluded that a long-term study was needed to determine if the amount of dietary fat, rather than dietary carbohydrate, might contribute to the development of diabetes mellitus in cats.

- Regardless of dietary protein or carbohydrate content, obesity led to severe insulin resistance in a study of obese cats, and weight loss normalized insulin sensitivity.

- In an epidemiologic study, indoor confinement and low physical activity were identified as risk factors for diabetes mellitus; however, the amount of dry food consumed was not.

- Effects of weight gain and feeding different amounts of carbohydrate (4%, 27%, 45%, or 56% DM) and fat were evaluated in a study of healthy cats that were fed dry food free choice before and after neutering. High dietary carbohydrate, relative to high fat, did not induce weight gain or increased plasma glucose and insulin concentrations in sexually intact cats. Gonadectomy stimulated food intake to the degree that undesired gains in body weight and fat occurred. The authors concluded that weight gain induced by high dietary fat and gonadectomy are probably more important to consider in the long-term health of cats than dietary carbohydrate content.

It is important that the veterinary health care team understand the above findings regarding this controversial topic. In general, the veterinary literature does not support a direct cause-and-effect relationship between increased carbohydrate or dry food intake and diabetes mellitus or obesity in cats. It appears likely that a combination of factors is involved: offering an increased dietary carbohydrate level indirectly affects a cat’s weight through free-choice feeding of dry food and subsequent obesity, which is associated with insulin resistance. In other words, feeding too many calories, not carbohydrate itself, is more likely the cause of obesity and increased risk for diabetes mellitus in cats.

How Much Carbohydrate Should Be Fed to Diabetic or Obese Cats?

Diabetes Mellitus

Some clinicians strongly recommend that foods for diabetic cats contain <7% carbohydrate (DM) to be effective; however, this is not supported by published evidence. Diabetic remission has occurred in 17% to 68% of cats fed amounts of carbohydrate ranging from 5% to 26% of calories. The highest remission rates occurred when cats were fed moist kitten foods with moderate amounts of protein (34% or 37% of calories) and 5% or 12% of calories as carbohydrate. No studies that have evaluated the effects of food have shown that feeding <12% of calories as carbohydrate is more beneficial, and the effects of feeding <6.9% carbohydrate (DM; 5% of calories as carbohydrate) have not been reported in diabetic cats.

Feeding increased fiber (cellulose) has been associated with improved glycemic control in cats with diabetes. In a study of diabetic cats fed a high-fiber food for 4 months, 41% experienced remission (i.e., no need for insulin). In the same study, feeding a low-carbohydrate, high-protein kitten food was associated with a significantly higher remission rate (68%).

In two studies, diabetic cats fed dry and/or moist high-protein, low-carbohydrate foods gained weight, most likely because dry food was offered free choice. It is possible that weight gain, which causes insulin resistance, resulted in lower remission rates.

In another study that evaluated a low-carbohydrate food, the best response was observed in obese diabetic cats, whereas diabetic cats with lower initial body fat continued to require insulin therapy to control clinical signs. Based on these findings, it seems reasonable that weight loss alone could result in diabetic remission in overweight cats regardless of nutrient intake (i.e., fewer calories, not less carbohydrate, are the cause); however, this needs to be
evaluated in future studies. In addition to dietary carbohydrate intake, other variables could have affected the occurrence of remission in reported studies, including insulin type and dose, duration of diabetes mellitus before treatment, intensity of glucose monitoring, change in percentage of body fat, and duration of treatment and monitoring.

Obesity

As with diabetic cats, nutritional management of overweight or obese cats most often involves feeding either a low-fat, high-fiber food or a low-carbohydrate, high-protein food. Both approaches can result in successful weight loss, and selection of a weight-management food is often based on personal preference and individual patient factors.14,21,54–59 Effects of time-limited feeding and dietary carbohydrate content on weight loss were studied in overweight, group-housed cats that were free-choice fed a reduced-energy, high-fiber, relatively high-carbohydrate food (Hill’s Science Diet Feline Light Adult Dry).14 The cats’ access to food was gradually restricted to 4 hours per day, and the cats were randomly assigned to continue receiving the reduced-energy food or to receive a therapeutic low-carbohydrate food (Purina DM Feline Formula Dry). On average, when the cats’ energy intake was restricted to the same degree, the cats lost weight at the same rate regardless of which food (or amount of dietary protein or carbohydrate) they received.

How Much Protein Should Be Fed to Promote Fat Loss and Maintain Lean Body Mass in Obese Cats?

Based on all available evidence, a range of dietary protein amounts (7.7 to 13.6 g/100 kcal) has been associated with weight loss and maintenance of lean body mass in cats.21,36,38,60 This amount of protein is found in most dry and moist therapeutic feline weight management foods. It has been recommended that overweight or obese cats be fed >45% of calories as protein to maximize fat loss and maintain lean body mass.31 This recommendation was partly based on the results of a study in which beneficial effects occurred in cats fed 45.2 g of protein per 100 g of food (11.1 g of protein per 100 kcal), not 45% of calories as protein.21 However, feeding this amount of protein does not guarantee maintenance of lean body mass, and some cats maintain lean body mass when fed less protein. In one study, cats that ate 7.7 g of protein per 100 kcal lost body weight with no significant change in lean body mass, while cats in another study lost lean body mass when eating a high-protein food (12 g/100 kcal).35,58 One study showed that cats that ate 9 g of protein per 100 kcal needed fewer calories to lose and maintain body weight compared with cats that ate more protein (11.9 g/100 kcal).60 In another study, heat production was greater in lean (but not obese) cats during consumption of a high-protein food (11.1 g/100 kcal) compared with consumption of less protein (6.9 g/100 kcal); increased heat production could decrease the likelihood of obesity developing over time.21 This was not supported by another study in which there was no difference in energy expenditure or loss of body fat when cats were fed a high-protein food (13.3 g/100 kcal) versus less protein (7.7 g/100 kcal).39 In addition, cats offered dry food free choice after neutering had significantly greater food intake and body weight gain when fed more protein (11 g/100 kcal) versus less protein (7.8 g/100 kcal).16

Veterinary Therapeutic Food Versus Over-the-Counter, Low-Carbohydrate Food

Pet owners often assume that over-the-counter foods (e.g., sold in grocery or pet stores) are less expensive; however, many of these foods cost more than therapeutic foods sold through veterinary hospitals. In general, over-the-counter foods are more convenient to purchase because they are more widely available than therapeutic foods. The disadvantages of some over-the-counter foods are that they contain excessive nutrients (e.g., calcium, phosphorus, sodium) and may have significant variability in nutrient content between products, especially between different flavors of the same brand. This results in lack of daily consistency in nutrient intake, which could affect glycemic control. Clinical studies usually use therapeutic foods; therefore, the effectiveness of these products is more likely to be supported by published evidence.

Summary and Recommendations

It is appropriate to recommend prescription canned food to manage specific feline disorders (e.g., feline idiopathic
cystitis, calcium oxalate urolithiasis, obesity, diabetes mellitus). Although not addressed in this article, it is also appropriate to consider the risks of feeding only canned food (e.g., the pathogenesis of feline diseases such as hyperthyroidism, the accumulation of dental plaque).  

Dry cat food has been identified as a risk factor for some feline diseases (e.g., obesity). However, current evidence does not support a cause-and-effect relationship between dry cat food and feline diseases. Regarding obesity and diabetes, the best treatment is prevention. It is important to assess how much food a cat is eating per day, and every effort should be made to maintain a cat’s ideal body condition throughout life. This requires that the veterinary team regularly communicate to pet owners (1) the consequences of feline obesity and (2) tips for helping cats maintain ideal body condition (e.g., meal feeding versus free-choice feeding, increased physical activity/play, environmental enrichment). Cats that are at increased risk for obesity (e.g., senior neutered males that continue to gain weight) should be identified, and the potential risks should be discussed during wellness examinations. Once diabetes mellitus develops, weight management is an important component of treatment, along with insulin therapy. Beneficial effects of consuming foods that contain between 5% and 26% of calories from carbohydrate (e.g., discontinuation of insulin therapy) have been observed in diabetic cats. Because some low-carbohydrate foods contain relatively higher amounts of protein, phosphorus, and fat, these foods may not be ideal for diabetic cats with concurrent conditions (e.g., urolithiasis, kidney disease, hepatic disease, pancreatitis). In these cases, the veterinarian must individualize treatment and decide what has the greatest effect on quality of life and longevity. The veterinary technician’s role is to continue discussing the treatment plan with the pet owner to ensure that he or she understands it and complies with the plan to maximize the pet’s health and longevity.

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References
27. Rand JS, Fleeman LM, Farrow HA, et al. Canine and feline diabetes...
1. The average carbohydrate (DM) content of dry grocery-brand cat foods is approximately
   a. 1% to 2%.
   b. 10%.
   c. 25%.
   d. 45%.

2. Carbohydrate becomes conditionally essential in cats during
   a. gestation.
   b. growth.
   c. lactation.
   d. all of the above

3. Most cat owners prefer to feed their cats
   a. time-restricted meals.
   b. one or two meals per day.
   c. dry food free choice.
   d. none of the above

4. Carbohydrate provides structural integrity to
   a. canned
   b. dry
   c. moist
   d. a and c

5. Free-choice feeding facilitates excessive caloric intake, which contributes to
   a. obesity.
   b. weight loss.
   c. weight gain.
   d. a and c

6. Which factor(s) affect the incidence of feline obesity?
   a. indoor confinement
   b. feeding dry food free choice
   c. low physical activity
   d. all of the above

7. In a study of ________ cats, feeding different carbohydrate sources had minimal effect on glucose and insulin responses.
   a. diabetic
   b. healthy
   c. obese
   d. indoor

8. Feeding increased ________ has been associated with improved glycemic control in cats with diabetes.
   a. protein
   b. fat
   c. fiber
   d. none of the above

9. Feeding ________ food can help overweight or obese cats lose weight.
   a. low-fat, high-fiber
   b. low-carbohydrate, high-protein
   c. a and b
   d. none of the above

    a. supports
    b. does not support
    c. has not been published regarding
    d. none of the above